Study of Variables Effecting Workforce Performance

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Abstract

Environmental factors such as lighting, temperature and relative humidity are important factors affecting the productivity of workers in the automotive industry. Therefore, the optimal parameters must be obtained to get the best productivity. Data collection was obtained by conducting the experiment in a simulated field is located in the UKM where the subject will perform the repetitive process of manually installing and productivity assessed for every 10 minutes. Environmental factors such as lighting, temperature and relative humidity are controlled and productivity levels will be recorded. From the data obtained, it will then be analyzed using the Taguchi method to obtain the optimum parameters. These results indicate that the optimum parameter for the temperature factor is 24 ° C, relative humidity factor of 40% and the brightness factor of 500 lux. Revenue contribution from this study will be used to help improve the country's automotive industry productivity.

Keywords: *Humidity, illuminance, optimum, productivity.*

Introduction

The automotive industry is one industry that contributes significantly to the revenue of the national economy. Therefore, healthy competition and there should be competitive in the industry to compete in the global market. Time is a factor that is often an issue on the productivity of an industry. Various research methods have been discovered and applied to optimize the productivity of industry as well as high quality products. According to the study, several factors have been identified as the cause of the decline in labor productivity. Therefore, the parameters must be obtained for the workstation environment is not only aimed to increase productivity and even ensure the comfort, health and safety of workers involved (Juslen 2007).Environment and a comfortable atmosphere is an important point because it can maintain focus and employee performance for a long time. If the focus of their impairment, this is what led to the decline in productivity, or worse, can result in accidents. Therefore, the values should be applied in ergonomic working environment for a comfortable environment and quality. The utility of ergonomics research is not limited to predicting and eliminating workplace injuries but can also be used to enhance productivity (Resnick & Zanotti, 1997).

A study on impact of lighting level on productivity by Juslen (2006) indicated that at higher illumination level (1200 lux as against 800 lux) shows increase in productivity. This study shows a change and improvement in lighting can have an effect on productivity. Juslen (2006) also found that by increasing an illumination levels it is possible to increase a person's productivity. This result in line with finding by Nicol *et.al* (2006) who claimed that there was a general satisfaction with the environment at higher level of illuminance. Previous research done by Cajochen (2007) show that the human alertness increase directly propotional with the increase of illuminance. This research was done to define and quantify the dose (illuminance levels) of light needed to evoke alerting responses in humans and their temporal relationship to light-induced changes in endocrinological and electrophysiological sequelae of alertness.

Humans can attempt to maintain their internal (core) temperature within an optimum range at around 37ºC and if the body is subjected to thermal stress the thermoregulatory system responds by changing its state in a way which is consistent with maintaining core temperature within this range (Parsons, 2000). Wijewardane & Jayasinghe (2008) had conducted the study of thermal comfort temperature range for factory workers in warm humid tropical climates. The results from this study showed that the ability to operate factory buildings as free running will be very useful in the context of saving energy needed from providing adequate thermal comfort for workers in warm humid tropical climatic conditions.

Relative humidity is a term used to describe the water vapor pressure of the air at given temperature (Bridger, 1995). It is one of the environmental factors that could give an influence towards workers' performance. Previous research done by Gavhed & Klasson (2005) showed that the low relative humidity resulted in more discomfort and more frequent symptoms in facial skin and the mucous membranes such as dryness of the mouth and throat, facial skin, more frequent symptoms of the eyes, lips and running nose. According to the Ishii et al. (1993), Japanese people might be more sensitive to humidity than westerners and so different methods from those used in the western countries should be required for human thermal environmental studies with respect to the hot humid summer in Japan. Tsutsumi et al. (2007) conducted a study to evaluate the effect of humidity on human comfort and productivity after step changes from warm and humid environment. The results of the study revealed that workers' performance was found to be at the same level under all conditions but to more tired at 70% RH after humidity step change meanwhile more evaporation of sweat from human body at lower humidity. The objective of this study was to

determine the dominance effects of environmental factors such as illuminance, humidity and WBGT on the workers performance at Malaysian manufacturing plant.

Methodology

The experimental layout is shown in Figure 1. This study was conducted in a room which is about 4.91 x 3:53 m which is modeled as a field of work similar to the work environment in selected industries. Therefore, the study can be conducted in a controlled environment. This room can accommodate one subject at a time and can also put some observation equipment for research. Three male workers has been selected as a subjects of study. Before the study began, a calibration of measurement equipment must be done. The aim is to determine the accuracy of a data device. Coordination calibration is done by using computer equipment to ensure that the calibration is done according to set standards. Subjects will perform the installation in the stands and on
every 10 minute period, the total production will be recorded. At this frequency is every 10 minutes, observation equipment will be monitored so that the room is a controlled environment as a set at the beginning of the study. The same set of parameters to be repeated by two other employees to obtain a more accurate reading. The experimental was carried out for 8 days in order to achieve the L_8 Taguchi design of experiment.

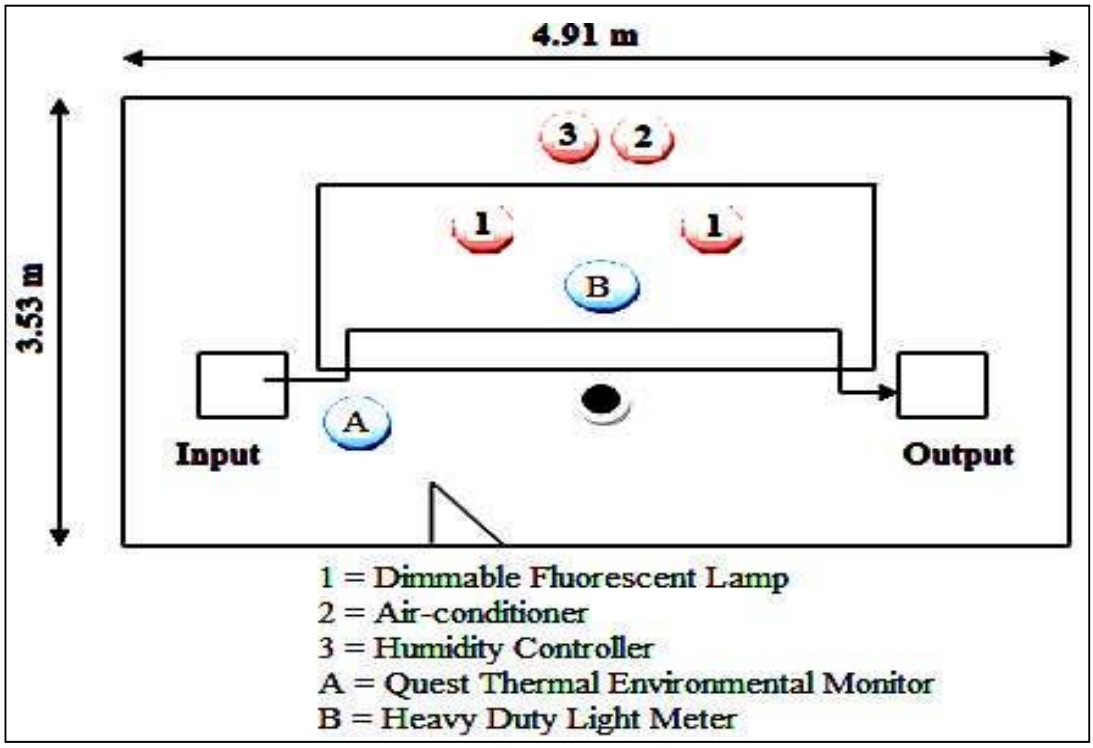

Figure 1: Experimental Layout

Table 1: Results of Average Worker Productivity Study

Experiment No.	Level of Parameters			Average Worker's Productivity, (unit)			Average Productivity (unit)
	WBGT Temperature (˚C)	Relative Humidity (%)	Illuminance (lux)	Worker 1	Worker 2	Worker 3	
1	24	40	200	0.899	0.852	0.854	0.870
2	24	40	500	1.244	1.126	1.326	1.232
3	24	70	200	0.877	0.862	0.927	0.886
4	24	70	500	1.006	1.182	1.157	1.115
5	32	40	200	0.852	0.868	0.842	0.853
6	32	40	500	0.894	1.086	0.883	0.954
7	32	70	200	0.711	0.701	0.672	0.690
8	32	70	500	0.792	0.762	0.815	0.790

Table 2: Results of ratio S/N of Productivity

Experiment No.	Level of Parameters			Average Productivity, (unit)	S/N Ratio, (dB)
	WBGT Temperature, (˚C)	Relative Humidity, (%)	Illuminance, (lx)		
1	24	40	200	0.870	-1.209
2	24	40	500	1.232	1.812
3	24	70	200	0.886	-1.051
4	24	70	500	1.115	0.945
5	32	40	200	0.853	-1.381
6	32	40	500	0.954	-0.409
7	32	70	200	0.690	-3.223
8	32	70	500	0.790	-2.047

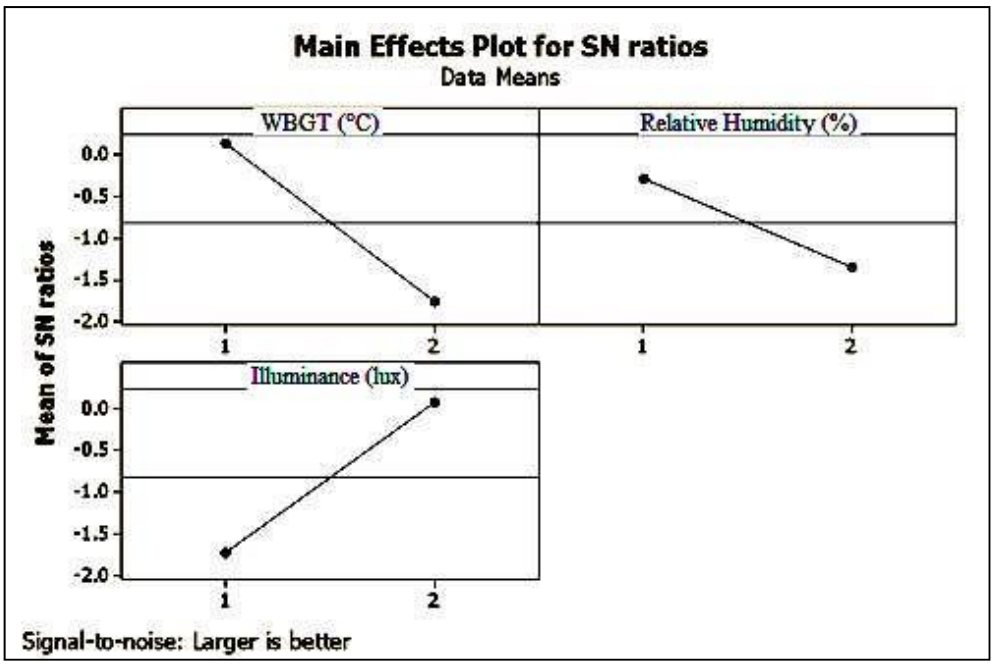

Figure 2: S/N Ratio Relationships between Environmental Factors on Productivity

Results and Discussion

From research and revenue data were collected, the results of the average productivity of three employees may be viewed as shown in Table 1. Minitab 15.0 software has been used for the purpose of the analysis the hypothesis. By using this software, it is able to get the value of optimization through Taguchi Method. Taguchi method is a good method to develop an experiment for the engineering process that involves a combination of several experimental parameters to obtain optimal results parameter. This method will then analyze the data using ANOVA analysis of the signal noise ratio (S/N ratio). Concept of signal noise ratio is a measurement of quality improvement. For the calculation of the data obtained, the signal noise ratio larger is better to be used. This is due to the productivity, the larger the better. This shows the growing production and the production of good quality. Table 2 below are the results of ratio S/N of productivity. Through mapping the data graph, it can show the difference between the average value of each level 1 and 2. The more significant difference means a greater influence on productivity. The difference ranges for each parameter level as shown in Figure 2. From Figure 2, the Y-axis for the graph represents as the value of S/N ratio while the X-axis represented the levels of these parameters. To such factors as temperature, level 1 indicates the value is greater than level 2. The value of level 1 is 0124, while level 2 is the -1765. The range of the two levels is of 1889. For the second factor is the relative humidity factor, the level 1 also shows a higher value than the level

Level 1 provides the ratio S / N of -0297 while level 2 is to provide a range of -1344 then the value of 1047. Further factor is the brightness factor, level 1 gives a value of - 1716 while level 2 is 0075. The range for the two levels is of 1791. Therefore, based on the range of S/N ratio is obtained, it can be concluded that the temperature factors are the most significant factors impact on productivity while the second biggest factor affecting productivity is followed by the brightness and relative humidity. This can be explained by taking into account the place of field studies in a private room where the three parameters to be studied will be controlled throughout the study was conducted. Thus, each parameter is fixed for a period of study. Thus, the factors involved are not influencing each other.

The optimum temperature was at 24 ˚ C. Optimum value for the relative humidity is 40% while the most optimum brightness value to employees is 500 lux. In this case, the maximum productivity is more than the value of 1.0. This parameter is valid as well as standards set by ISO 7730 which states that the temperature at 24 ° C - 27 ° C is the best temperature for the convenience of employees. Referring to Tsutsumi et al (2007), he says that the best relative humidity range is between 40% to 50%.

Therefore, the results of the Taguchi method of analysis also shows the relative humidity range for this study is similar to the results of research done by him. For the results of brightness, the brightness of 500 lux is meeting the standards set by the European Standard (EN 12464-1:2002), which states that the brightness 500lux is best used for installation works in the automotive industry.

Conclusion

Overall, this study has met the objectives and scope of the target. From the data analysis was performed by Taguchi method, the relationship between environmental factors to productivity have been obtained. The optimum temperature was at 24 ˚ C. Optimum value for the relative humidity is 40% while the most optimum brightness value to employees is 500 lux. This study was done to prove empirically the previous perception studies, which based on the role of environmental factors to human performance. The results might vary for test carried out for different sample sizes, type of

industries and countries. However, the research findings are restricted to the Malaysian workplace environment, where the awareness among workers on improving the productivity is still low.

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